무선 네트워크에서 사전 핸드오버를 위한 프레임워크

A Framework for Proactive Handover in Wireless Networks

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Abstract

Handover is constantly a challenging issue in wireless networks. Most of the existing solutions are host-based, which are implemented on the wireless terminals and leave the decision making to the terminals. This paper studies the problem of network-based handover in the wireless networks with the constraints of low latency as well as low computational time. To address this problem, we employ the software-defined network (SDN) architecture to facilitate handover. According to the operational model of the SDN, we define a workflow for all involved network entities, and then design a framework implementing the workflow as a complete handover system. The proposed framework aims to establish a channel conveying the mobility-related information of devices and the context information of their vicinity from the switches/access routers to the controllers. Based on collected information, the controller can optimally execute the handover.

1. Introduction

The advance of the wireless mobile communications nowadays allows mobile users to use network services without any intermittence while traveling. This is actually supported by a handover technique [1] which lets a mobile device, a mobile node (MN), to keep its connection active when it moves from one access router (AR) to another. In a handover process, the MN triggers a handover event under some certain conditions. Then the network identifies new resources for the handover connection and performs additional routings. The handover process requires some time for transferring the MN between ARs. This causes packet loss during communications. The longer the handover process is, the more packet loss the mobile user incurs.

The emergence of software-defined network (SDN) [2] makes the network management become more efficiently. SDN centralizes the control of the network into a single entity called controller. With a complete view of the network, the controller can make decision efficiently in routing, providing QoS, and so on. Regarding handover process, it is highly beneficial if the MN is attached to the best-suited AR among all available. Such an AR could be in a low-load state, or on a reliable path to the destination. Moreover, it is more beneficial if the AR is informed about the coming connection to prepare necessary resources prior to establishing connection with the MN. With the support of SDN, achieving aforementioned advantages becomes feasible.

In this paper, we investigate the problem of minimizing the handover latency in wireless networks and design a framework to facilitate the handover with a low latency so that the packet loss will be minimized and the QoS hence will be increased. Our handover framework adopts the SDN concept. Specifically, we provide an application at each AR to monitor all the MNs in its vicinity. Information of MNs is reported to the controller periodically. Using the information from ARs, the controller can make a series of actions to identify the time for handover an MN, to pinpoint the next in-charge AR, and then inform the AR to get ready for the MN to attach.

2. Related Work

Handover procedure is generally categorized as horizontal, vertical and diagonal handovers [3]. It is also considered as two different types, handover in layer 2 or layer 3. Much effort has been made to find solutions for handover where different metrics are evaluated for making the decision such as the signal strength, network load, service cost, handover latency, user preferences, security, throughput and so on. Dozens of schemes have been proposed in the literature, which adopt diverse criteria in making handover decision and also employ different methodologies to process the handover. Those can be known as received signal strength (RSS) based schemes, QoS-based schemes, Network Intelligence based schemes, or Context-based schemes. Although all those schemes achieve significantly improvement, they introduce a lot of overhead in terms of computational complexity which makes the commercial product unfeasible.

To our best knowledge there is no work presented in the literature, which utilizes SDN to tackle the handover procedure. In our framework employing SDN, with a centralized controller it is possible to utilize all criteria and methodologies at once to provide a better strategy of handover. Additionally, because the decisions are made by the controller, we define a decision function at the controller which can evaluate all the aforementioned metrics in a predetermined way for an efficiently decision making. The results obtained by our framework will certainly outperform other existing schemes.

3. The Framework for Proactive Handover

3.1. Overview

The aim of the proposed framework is to minimize the latency of handover MNs in a wireless network. This is accomplished by a process of selecting the best AR and proactively preparing the AR prior to the attachment of the MN. Thanks to this after detaching from the previous AR, the MN can attach to the best AR on the way. By continuously monitoring of all MNs in the vicinity, an AR has a local view of these MNs' status. Different local views of ARs are used for making decisions of handover the MNs effectively at the controller.

The design of the handover framework includes three separate key modules in ARs and the controller: the information collector (IC) and the local decision maker (LDM) in the AR, and the global decision maker (GDM) in the controller. Moreover, a scheme which defines how these modules work as well as how they communicate with each other is also proposed. For a detail depiction, hereafter we present the framework architecture, the handover scheme, and then we describe the implementation of both the framework and the scheme.

3.2. The Framework Architecture

There are three main operational entities in our framework: the MN, the AR and the controller. The MN is assumed to communicate with a server or another corresponding node (CN). All ARs in the vicinity of the MN can overhear the signal transmitted by the MN, collect all those signals, extract the useful information of the MN's status and make a decision (by its local decision function) whether to report these information to the controller. The controller captures all the information sent by ARs and globally makes the decision of handover for a MN if needed. Fig. 1 shows the entities and the relation between them.

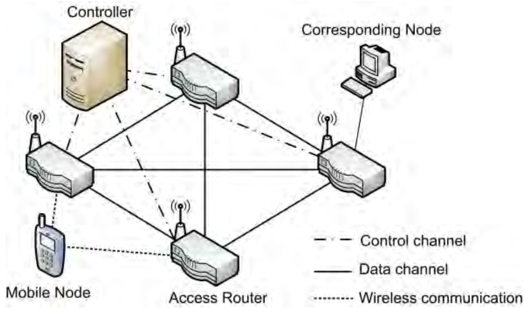

Fig 1. Entities in the handover framework.

The framework is equipped with a platform to which the IC can be hooked. This platform provides an API and a communication channel for the collector to communicate with the LDM, and then from which collected information of MNs can be delivered to the controller if needed. For future extension, we design the platform for general-purpose applications. Hence the platform can provide services to diverse applications besides the IC, such as collectors for different kinds of information, or some signaling applications which send commands to the MNs. Fig. 2 presents the proposed platform.

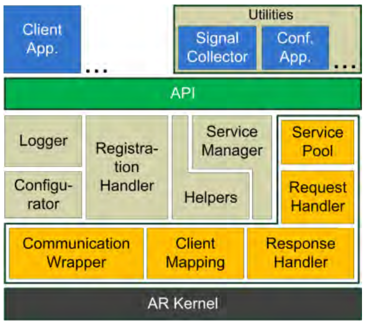

Fig. 2. The communication platform in an AR.

3.3. The Handover Scheme

Without loss of generality, we just consider the signal strength of the MN captured by the ARs as the information to be extracted. In other word, the signal strength becomes an input metric of the decision functions at both the AR and the controller. Our scheme could be seen as the RSS-based scheme; but with a centralized controller, the scheme can be extended by a modification just in the decision functions. Hereafter are the depictions of related modules and how each of them works.

- The IC periodically collects the signal strength of all MNs in its vicinity. The signal strengths of each MN are all cached to calculate the exponentially weighted moving average (EWMA) according to the following formula and then the result is reported to the LDM.

$$x_i = \alpha x_{i-1} + (1-\alpha)t_i$$

where x_i denotes the (EWMA) result at current time, x_{i-1} denotes the previous result, t_i denotes the current sampled data (signal), and α is a weighted factor.
- The LDM makes the local decision whether to send the signal strength to the controller. To facilitate this, we define two thresholds the HT (high threshold) and the LT (low threshold). The signal strength of an MN captured by an AR is reported to the controller if it becomes worse or better compared with the current state which is in the range between the HT and LT. In case the signal strength of a MN varies but within some ranges that lower than the LT or higher than the HT, the AR does not need to report about this to the controller. It is because this is either very bad signal or perfect one and no change should be made. The LDM is designed as a separate module for easy to extend in the future. It will be able to take into account other metrics for locally making the decision.
- The GDM makes the decision of handover an MN based on the all collected data of the MN sent by ARs. For simplicity, the GDM currently takes only the signal strength into account. It will be extended to communicate with other modules besides the IC to collect diverse information to make the final decision more efficiently. Those information become the input metrics of the decision function, which are evaluated with different weighting factor, and then are combined as a central metric to identify the best AR for the MN to be attached to.

4. Conclusion

In this paper, a framework for proactive handover in wireless networks is presented. With a scheme of identifying the next AR and proactively preparing the necessary resources at the AR prior to the handover, our framework can significantly reduce the handover latency which in turn decreases the rate of packet loss.

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